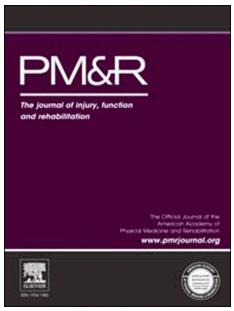
Accepted Manuscript



Effects of Low-Load Exercise on Post-needling Induced Pain After Dry Needling of Active Trigger Point in Individuals with Subacromial Pain Syndrome

Jaime Salom-Moreno, PT, PhD;, Laura Jiménez-Gómez, PT, Victoria Gómez-Ahufinger, PT, María Palacios-Ceña, PT, MSc;, José L. Arias-Buría, PT, PhD;, Shane L. Koppenhaver, PT, PhD;, César Fernández-de-las-Peñas, PT, PhD, DMSc

PII: S1934-1482(16)31008-5

DOI: 10.1016/j.pmrj.2017.04.012

Reference: PMRJ 1896

To appear in: *PM&R*

Received Date: 17 October 2016

Accepted Date: 15 April 2017

Please cite this article as: Salom-Moreno J, Jiménez-Gómez L, Gómez-Ahufinger V, Palacios-Ceña M, Arias-Buría JL, Koppenhaver SL, Fernández-de-las-Peñas C, Effects of Low-Load Exercise on Post-needling Induced Pain After Dry Needling of Active Trigger Point in Individuals with Subacromial Pain Syndrome, *PM&R* (2017), doi: 10.1016/j.pmrj.2017.04.012.

Title Page

Effects of Low-Load Exercise on Post-needling Induced Pain After Dry Needling of Active Trigger Point in Individuals with Subacromial Pain Syndrome

Authors

Jaime Salom-Moreno[1,2] PT, PhD; Laura Jiménez-Gómez[1] PT; Victoria Gómez-Ahufinger[1] PT; María Palacios-Ceña[1,2] PT, MSc; José L. Arias-Buría[2,3] PT, PhD; Shane L. Koppenhaver[4] PT, PhD; César Fernández-de-las-Peñas[1,2] PT, PhD, DMSc;

Affiliations

(1) Department of Physical Therapy, Occupational Therapy, Rehabilitation and Physical Medicine, Universidad Rey Juan Carlos, Alcorcón, Spain

(2) Cátedra de Investigación y Docencia en Fisioterapia: Terapia Manual y Punción Seca, Universidad Rey Juan Carlos, Alcorcón, Madrid, Spain.

(3) Department of Physical Therapy, Universidad Francisco de Vitoria, Spain

(4) U.S. Army-Baylor University Doctoral Program in Physical Therapy, San Antonio, TX, USA

Address for reprint requests / corresponding author.

César Fernández de las Peñas
Facultad de Ciencias de la Salud
Universidad Rey Juan Carlos
Avenida de Atenas s/n
28922 Alcorcón, Madrid, SPAIN
E-mail address: cesar.fernandez@urjc.es

Telephone number: + 34 91 488 88 84

Fax number: + 34 91 488 89 57

Disclosures: Financial disclosure statements have been obtained. No conflicts of interest have been reported by the authors or by any individuals in control of the content of this article.

Abstract word account: 250 words / **Main text word account:** 2,950 words

Reference account: 38 / **Table account**: 3 / **Figure account**: 4

Effects of Low-Load Exercise on Post-needling Induced Pain After Dry Needling of Active Trigger Point in Individuals with Subacromial Pain Syndrome

Abstract

Background: Application of dry needling is usually associated to post-needling induced-pain. Development of post-needling intervention targeting to reduce this adverse event is needed.

Objective: To determine the effectiveness of low-load exercise on reducing post-needling induced-pain after dry needling of active trigger points (TrPs) in the infraspinatus muscle in subacromial pain syndrome.

Design: A 72h follow-up, single-blind randomized controlled trial.

Setting: Urban hospitals.

Participants: Individuals with subacromial pain syndrome (n=90, 52% female, mean age: 35±13 years) with active TrPs in the infraspinatus muscle.

Interventions: All individuals received dry needling into infraspinatus active TrP. Then, they were randomly divided into experimental group, which received a single bout of low-load exercise of shoulder muscles; placebo group, which received inactive ultrasound for 10min; and control group, which did not receive any intervention.

Outcome Measures: Numerical pain rate scale (NPRS, 0-10 point) at post-needling, immediate post-intervention (2min), and 24h, 48h, and 72h after needling. Shoulder pain (NPRS, 0-10) and disability (DASH: Disabilities of the Arm, Shoulder and Hand; SPADI: Shoulder Pain and Disability Index) were assessed before and 72h after needling.

Results: The 5x3 ANCOVA showed that the exercise group demonstrated a larger decrease in post-needling induced-pain immediately after (P=.001), 24h (P=.001) and 48h after (P=.006) than placebo or control groups. No differences were found at 72h (P=.03). Similar improvement in shoulder pain (P<.001) and related-disability (DASH: P<.001; SPADI:

P<.001) was observed 72h after needling irrespective of the treatment group. **Conclusions**: Low-load exercise was effective for reducing post-needling induced-pain on active TrPs in the infraspinatus muscle 24h and 48h after needling. The application of post-needling intervention did not influence short-term pain and disability changes.

Key words: dry needling, shoulder pain, exercise, trigger point

Effects of Low-Load Exercise on Post-needling Induced Pain After Dry Needling of Active Trigger Point in Individuals with Subacromial Pain Syndrome

Introduction

Trigger points (TrPs) are defined as hypersensitive tender spots within taut bands of skeletal muscles that are painful on mechanical stimulation, elicit a referred pain, generate motor dysfunction, and autonomic response [1]. Active TrPs are those provoking spontaneous symptoms and which referred pain reproduce, total or partially, the symptoms experienced by patients [1]. It has been reported that active TrPs reproduce the symptoms experienced by individuals experiencing mechanical neck pain [2], lateral epicondylitis [3], whiplash [4], tension-type headache[5,6], fibromyalgia [7,8], temporomandibular pain [9], or shoulder pain [10,11].

Several therapeutic approaches are proposed for the management of myofascial pain to include a growing trend of trigger point dry needling (TrP-DN) [12]. TrP-DN is defined as a "skilled intervention using a thin filiform needle to penetrate the skin that stimulates TrPs, muscles, and connective tissue for the management of musculoskeletal disorders" [13]. Recent meta-analyses suggest that TrP-DN may be effective for the management of neck and shoulder pain [14,15]. Significant adverse effects associated with the use of TrP-DN are rare, but some mild adverse events such as pain during and after needling, bleeding or bruising are fairly common [16]. Post-needling induced pain or soreness is reported as one of the most common side effects of TrP-DN and is thought to be a consequence of neuromuscular damage generated by the repetitive needling insertions into the muscle [17]. The presence of post-needling soreness has been associated with a possible reluctance to receive further needling therapy by individuals with myofascial pain, generating patient

dissatisfaction and reduced treatment adherence [18]. In fact, the American Physical Therapy Association (APTA) recommends warning patients about the presence of soreness after TrP-DN [19]. Therefore, it is relevant to determine if clinicians are able to reduce post-needling induced-pain by post-intervention strategies.

There are few studies investigating therapeutic strategies to decrease post-needling induced-pain. Two recent studies demonstrated that application of spray and stretch [20] and ischemic compression [21] after TrP-DN exhibited short-term effects (between 6-24 hours) for reducing post-needling soreness on latent TrPs in the upper trapezius. While promising, these studies included asymptomatic subjects with latent TrPs, which does not represent clinical practice, and also applied passive modalities for reducing post-needling soreness. It is possible that active exercise may be more functional, time efficient and empowering to patients than passive treatments after TrP-DN. A recent study has reported that low-load eccentric exercise provided protection against damage [22]. It is possible that application of low-load exercise after TrP-DN help to decrease post-needling soreness by protecting against muscle damage. To the best of the author's knowledge, no previous study has determined the effectiveness of any intervention on post-needling soreness in symptomatic individuals exhibiting active TrPs.

Therefore, our aim was to determine the effectiveness of low-load eccentric exercise on reducing induced-pain after dry needling of active TrPs in the infraspinatus muscle in subacromial pain syndrome. We hypothesized that subjects receiving low-load exercise as TrP-DN post-intervention would exhibit higher reduction of post-needling induced-pain and greater improvements in pain and disability than those receiving detuned (inactive) ultrasound or no intervention.

Methods

Study Design

A randomized, parallel-group, controlled trial was conducted to compare the effects on post-needling soreness of low-load eccentric exercise (experimental), detuned ultrasound (placebo), no intervention (control) in subacromial pain syndrome. The study was approved by the Institutional Review Board of Universidad Rey Juan Carlos (URJC 20072015341531/2014). The trial was registered (ClinicalTrials.gov: NCT02558686).

Participants

Consecutive subjects with a diagnosis of subacromial pain syndrome from different regional Hospitals of Madrid (Spain) were screened for eligibility criteria. Subacromial pain syndrome was defined when individuals fulfilled the following: 1, unilateral shoulder pain complaints persisting from at least 6 months; 2, pain intensity >3 points on an 11-point numerical pain rate scale (NPRS); 3, a positive painful arc test during abduction (+LR 3.7, 95%CI 1.9-7.0) [23]; and, 4, at least 2 positive of these tests: Hawkins-Kennedy test (+LR 1.70, 95%CI 1.29-2.26), Neer's sign (+LR 1.86, 95%CI 1.49-2.31), empty can test (specificity 0.62), drop arm test (specificity 0.92), or lift-off test (specificity 0.97) [24].

Additionally, subjects exhibited at least one active TrP in the infraspinatus muscle reproducing their shoulder symptoms. TrP diagnosis was performed following the criteria described by Simons et al [1]: 1, presence of a hypersensitive spot in a palpable taut band in the infraspinatus muscle; 2, local twitch response elicited by snapping palpation of the taut band; and 3, referred pain in response to compression. To be considered active, the elicited pain by the TrP should reproduce any symptom experienced by the subject and the subject

recognized the pain as familiar. These criteria, when applied by trained assessors, have exhibited a moderate inter-examiner reliability (k: 0.65-0.88) [25].

The infraspinatus muscle was selected for the following reasons: 1, it is the muscle most frequently affected by TrPs in individuals with shoulder pain [10,11]; 2, the referred pain elicited by its TrPs spreads to the shoulder area [1] mimicking symptoms experienced by individuals with subacromial pain syndrome [10,11]; 3, it is superficial and accessible to manual palpation and treatment; 4, it has shown the highest agreement about the presence or absence of TrPs (70%-80%) in relation to other rotator cuff muscles [26]; 5, since it is a posterior muscle, differentiation of post-needling induced-pain from the shoulder symptoms would be easier for the participants since they usually report symptoms in the anterior and lateral parts of the shoulder region.

Participants were excluded if they exhibited any of the following: 1, bilateral shoulder pain; 2, fear of needles; 3, coagulation disorders; 4, history of shoulder fractures and/or dislocation; 5, cervical radiculopathy; 6, previous intervention with steroid injections in the shoulder; 7, fibromyalgia syndrome; 8, previous history of shoulder or neck surgery; 9, any therapeutic intervention for the shoulder area the previous year. All participants signed an informed consent prior to their inclusion in the study.

Randomization and masking

Subjects were randomly assigned to receive one intervention. Concealed allocation was done using a computer-generated randomized table of numbers created by an external statistician. Individual and sequentially numbered index cards with the random assignment were prepared, folded, and placed in sealed opaque envelopes. A second researcher opened the envelope and proceeded with subject allocation. All outcomes were assessed by another investigator who was blinded to group assignment.

Dry needling procedure

All participants received TrP-DN to an active TrP in the infraspinatus muscle by a physical therapist with 10 years of experience with this procedure. TrP diagnosis and TrP-DN was applied by the same clinician in all participants. Since the infraspinatus muscle can exhibit multiple active TrPs [27], a clinical/pragmatic approach was applied. If multiple active TrPs were found, the clinician selected the most painful for receiving TrP-DN. Once the TrP was located, the skin was cleaned with alcohol. Participants received TrP-DN with disposable stainless steel needles of 0.32mm*40mm (Novasan©, Madrid, Spain) that were inserted into the skin over the TrP and advanced into the muscle using the fast-in and fast-out technique described by Hong [28] until a local twitch response was obtained. The depth of the needle typically ranged from 10mm to 15 mm depending on the muscle thickness (**Fig. 1**). Once the first local twitch response was obtained, the needle was moved up and down (3 to 5 mm. vertical motions, no rotations) until no more local twitch responses were elicited [28]. Upon removal of the needle, the area was compressed firmly with a cotton bud for approximately 1 minute.

Post-needling interventions

Participants assigned to the experimental group received a session of low-load exercise of the shoulder musculature focusing on the infraspinatus muscle with the patient supine. One set of 12 repetitions was conducted. Each repetition included a self-paced concentric phase, followed by a very slow and controlled eccentric phase lasting about 5sec (**Fig. 2**). A medium resistance TheraBand© was used for conducting low-load pain-free contraction.

Individuals assigned to the placebo group received 10 minutes of detuned (inactive) ultrasound on the area receiving the TrP-DN on the infraspinatus muscle.

Finally, those assigned to the control group did not receive any intervention and they were asked to rest on the table for 10 minutes.

Outcome Measures

The primary outcome included the intensity of post-needling induced-pain with an 11-point NPRS (0: no pain; 10: maximum pain) [29]. It was defined as tenderness and/or pain perceived around the TrP receiving the dry needling procedure. Post-needling induced-pain was assessed before the post-needling intervention (baseline), and 2min (immediate post), 24h, 48h and 72h after the post-needling intervention by an assessor blinded to the subject's allocation.

Secondary outcomes included shoulder pain and disability and were assessed before TrP-DN and 72 hours after the intervention. A separate 11-point NPRS (0-10) was used to assess the patients' current level of shoulder pain. Mintken et al reported that the minimal clinically important difference (MCID) for the NPRS in individuals with shoulder pain is 1.1 points [30]. Participants were asked for differentiating between their shoulder pain and TrP-DN induced-pain.

Shoulder-related disability was assessed with the most commonly used questionnaires [31]: the Disabilities of the Arm, Shoulder and Hand (DASH) and Shoulder Pain and Disability Index (SPADI). The DASH is a 30 items questionnaire assessing: 1, degree of difficulty the preceding week in performing physical activities because upper extremity problems (21 items); 2, severity of each symptom, activity-related pain, tingling, weakness, and stiffness (5 items); and 3, the effect of shoulder pain on social activities, work, and sleep, and its psychological impact (4 items) [32]. Each item is answered on a 5-points scale ranging from 1 (no difficulty to perform, no symptoms, or no impact) to 5 (unable to do, severe symptoms, or high impact). Responses are summed to form a raw score that is

converted to a 0 to 100 score where higher score reflect greater disability. The Spanish version of the DASH has shown high internal consistency (Cronbach α: 0.96) and excellent test-retest reliability (r: 0.96) [33]. It has been recently reported that the MCID for the DASH is 10.81 points [34].

The SPADI is a 13-items shoulder function index assessing pain and disability related to shoulder dysfunction [35]. Each item is scored by a numeric rate scale ranging from 0 (no pain/no difficulty) to 10 (worst pain imaginable/so difficult it required help). The total score ranges from 0 to 100 points where a higher score indicates greater disability. The Spanish version of the SPADI has exhibited high internal consistency (Cronbach α: 0.916) and excellent test-retest reliability (ICC: 0.91) [36]. It has been recently reported that MCID for the SPADI ranges from 8 to 13 points [37].

Sample size determination

The sample size was calculated using Ene 3.0 software (Autonomic University of Barcelona, Spain). The calculations were based on detecting differences of 1.1 points (the MCID) [30] in the primary outcome (post-needling induced-pain) at follow-up, assuming a standard deviation of 1.35, a 2-tailed test, an alpha level (α) of .05, and a desired power (β) of 80%. The estimated desired sample size was calculated to be 25 individuals per group. Allowing for a 20% dropout rate, we recruited 30 subjects per group.

Statistical Analysis

Statistical analysis was performed using SPSS software, version 21.0 (Chicago, IL, USA). Mean, standard deviation (SD), and 95% confidence interval (CI) for each variable were calculated. The Kolmogorov-Smirnov test showed that all quantitative data showed a normal distribution (P>.05). Baseline data were compared among groups using a 1-way

analysis of variance (ANOVA) tests for continuous data and $\chi 2$ tests of independence for categorical data. For the main outcome measure a 5x3 mixed-model analysis of co-variance (ANCOVA) with time (baseline, and 2min, 24h, 48h, 72h after intervention) as the within-subjects factor, group (experimental, placebo, control) as the between-subjects factor and gender as the covariate was used to determine the effect of each intervention on post-needling induced-pain. A 2x3 mixed model ANCOVA with time (before and 72h after TrP-DN) as the within-subjects factor, group (experimental, placebo, control) as the between-subjects factor and gender as the covariate was used to determine the effects of TrP-DN on pain and disability. Gender was used as covariate since prior research suggests that women experience more post-needling soreness than men [38]. For each ANCOVA, the hypotheses of interest was the Group*Time interaction. Post hoc analyses were conducted with the Bonferroni test using a corrected alpha of .017 (3 independent-samples). Consistent with the intention to treat principle, all data was analyzed to the group that the participant was assigned.

Results

One hundred and twenty-five (n=125) patients with shoulder pain were screened for eligibility criteria. Ninety patients (mean ± SD age: 35±13 years; 52% female) satisfied the eligibility criteria, agreed to participate, and were randomized into experimental (n=30), placebo (n=30), or control (n=30) group. The reasons for ineligibility are found in **Fig. 3**. Baseline data among the groups were similar for all variables (**TABLE 1**).

Post-needling induced-pain

The 5x3 mixed-model ANCOVA revealed a significant Group*Time interaction (P<.001), with no effect of gender (P=.54), for changes in post-needling induced-pain. Post hoc analysis showed that the exercise group exhibited a higher decrease in post-needling induced-pain immediately after (P=.001), 24h after (P=.001) and 48h after (P=.006) than did the placebo or control group (**Fig. 4**). No significant differences were observed at 72h (P=.03). **TABLE 2** provides the evolution of post-needling induced-pain in all groups.

Shoulder pain and related-disability

The 2x3 mixed model ANCOVA did not reveal any statistically significant Group * Time interaction for shoulder pain (P=.48), DASH (P=.75), or SPADI (P=.98). However, there were main effects for time with all groups reporting similar improvements in shoulder pain (P<.001), DASH (P<.001), and SPADI (P<.001) after TrP-DN. Gender did not influence the main effect for any outcome (pain: P=.55; DASH: P=.84; SPADI: P=.72). **TABLE 3** provides baseline and 72h post-intervention data as well as within-group differences with their 95%CI for shoulder pain and related-disability.

Discussion

We found that application of one set of 12 repetitions of low load contractions was more effective for reducing post-needling induced-pain from active TrPs in the infraspinatus muscle immediately after, 24h and 48h after TrP-DN in subacromial pain syndrome than was placebo or control interventions. No differences were found in post-needling induced-pain 72h after TrP-DN between interventions. Likewise, there were no differences in pain or disability outcomes between the different interventions; rather, these outcomes improved

279 to a similar degree regardless of the treatment group. Finally, gender did not influence the
280 outcomes.

281 This is the first study investigating the effects of low-load exercise as a post-needling
282 intervention in active TrPs. Previous studies investigating post-dry needling interventions
283 were conducted on asymptomatic subjects exhibiting latent muscle TrPs [20,21]. Similarly
284 to previous studies, post-needling soreness was present in 100% of the individuals who
285 received TrP-DN in our study. In contrast with previous studies, post-needling induced-
286 pain did not completely disappear 72h after the needling procedure, although pain levels
287 were relatively small. This can be related to the fact that previous studies investigated latent
288 TrPs in asymptomatic people [20,21], whereas in our study we included symptomatic
289 subjects with active muscle TrPs. Combing clinical experience and available scientific data,
290 it seems that post-needling soreness tends to disappear 72h after the application of TrP-DN,
291 without any post-needling intervention. Nevertheless, short-term reduction of post-needling
292 induce-pain may be important for patient's perception of recovery since those individuals
293 experiencing strong post-needling soreness may refuse to receive further needling treatment
294 [39].

295 We observed that individuals receiving low-load exercise after TrP-DN exhibited a
296 larger decrease in post-needling induced-pain than those receiving detuned ultrasound or
297 those who did not receive any intervention. Between-group change scores surpassed the
298 MCID for the main outcome [30] in favor of the exercise group immediately after, 24h and
299 48h after; however, clinical relevance of the observed changes should be considered with
300 caution since the lower bound of the 95% confidence interval for between-groups change
301 scores was equal to the MCID in some patients. In fact, the greatest post-needling pain
302 reduction after exercise was observed immediately after the intervention (2.8, 95%CI 2.1,

3.5), surpassing the MCID of 1.1 points to be considered as a clinically significant change in patients with shoulder pain [30]. It is interesting to note that the reduction in post-dry needling induced-pain observed after exercise in our study was similar to those previously observed with the application of spray and stretch or ischemic compression in latent TrPs in the upper trapezius muscle [20,21]. We do not know the effects of these last two techniques on post-needling soreness in active TrPs.

Additionally, there were no differences between women and men in the reduction of post-needling induced-pain after either intervention. A recent study found that women reported significantly higher intensity of post-needling soreness than men immediately after needling, 5min after and 12h after needling of latent TrPs in the upper trapezius; however, this study did not investigate gender differences on the response to any intervention after the needling procedure [38]. Our study suggests that no differences exist in the response to interventions applied for decreasing post-needling induced-pain between women and men with active TrPs. Further studies are required to determine if other gender differences exist.

Finally, we also observed that, regardless of the post-needling intervention received, all groups experienced similar short-term improvements in shoulder pain and disability 72h after TrP-DN in the infraspinatus muscle. Within-groups change scores and their 95%CI surpassed the MCID for pain [30] and related-disability [34,37]. This suggests a potential clinical finding since the decreases in post-needling induced-pain was associated with improvement in shoulder pain and disability. Therefore, it is possible that TrP-DN maybe effective for the management of individuals with subacromial pain syndrome; however, the lack of a control group not receiving TrP-DN does not permit to determine the effectiveness of the intervention. Future randomized clinical trials investigating the effectiveness of TrP-DN in the shoulder musculature should clarify this hypothesis.

The results of the current study should be considered according to some limitations. First, only one active TrP received the needling intervention; therefore, we do not know if the same results would be obtained if a greater number of active TrPs in the same muscle or different muscles receive the needling intervention. Second, multi-center studies would help to better generalization of the results. Third, patients were not blinded to post-needling intervention since it is difficult to obtain a sham-exercise. Finally, we did not consider the role of psychological variables, e.g., depression, anxiety, mood, or somatization.

Conclusions

This study found that application of a low-load exercise was effective for reducing post-needling induced-pain on active TrPs in the infraspinatus muscle immediately after, 24h and 48h, but not 72h, after the intervention in people with subacromial pain syndrome. No gender differences were observed. The application of any intervention after TrP-DN did not influence short-term shoulder pain and related-disability outcomes.

References

1. Simons DG, Travell JG, Simons LS. Myofascial Pain and Dysfunction: The Trigger Point Manual (Vol 1). 2nd ed. Baltimore: Williams & Wilkins; 1999.
2. Fernández-de-las-Peñas C, Alonso-Blanco C, Miangolarra JC. Myofascial trigger points in subjects presenting with mechanical neck pain: a blinded, controlled study. Man Ther 2007; 12: 29-33.
3. Fernández-Carnero J, Fernández-de-las-Peñas C, de la Llave-Rincon AI, Ge HY, Arendt-Nielsen L. Prevalence of and referred pain from myofascial trigger points in the forearm muscles in patients with lateral epicondylalgia. Clin J Pain 2007; 23: 353-60.
4. Fernández-Pérez A, Villaverde-Gutiérrez C, Mora-Sánchez A, Alonso-Blanco C, Sterling M, Fernández-de-las-Peñas C. Muscle trigger points, pressure pain threshold, and cervical range of motion in patients with high level of disability related to acute whiplash injury. J Orthop Sports Phys Ther 2012; 42: 634-641.
5. Fernández-de-las-Peñas C, Cuadrado ML, Arendt-Nielsen L, Simons DG, Pareja JA. Myofascial trigger points and sensitization: An updated pain model for tension-type headache. Cephalalgia 2007; 27: 383-393.
6. Arendt-Nielsen L, Castaldo M, Mechelli F, Fernández-de-las-Peñas C. Muscle triggers as a possible source of pain in a sub-group of tension type headache patients?. Clin J Pain. 2016; 32: 711-8.
7. Alonso-Blanco C, Fernández-de-las-Peñas C, Morales-Cabezas M, Zarco-Moreno P, Ge HY, Florez-García M. Multiple active myofascial trigger points reproduce the overall spontaneous pain pattern in women with fibromyalgia and are related to

widespread mechanical hypersensitivity. Clin J Pain 2011; 22: 405-413.

8. Ge HY, Wang Y, Fernández-de-Las-Peñas C, Graven-Nielsen T, Danneskiold-Samsøe B, Arendt-Nielsen L. Reproduction of overall spontaneous pain pattern by manual stimulation of active myofascial trigger points in fibromyalgia patients. Arthritis Res Ther 2011; 13: R48.
9. Fernández-de-las-Peñas C, Galán-del-Río F, Alonso-Blanco C, Jiménez-García R, Arendt-Nielsen L, Svensson P. Referred pain from muscle trigger points in the masticatory and neck-shoulder musculature in women with temporomandibular disorders. J Pain 2010; 11: 1295-304.
10. Hidalgo-Lozano A, Fernández-de-las-Peñas C, Alonso-Blanco C, Ge HY, Arendt-Nielsen L, Arroyo-Morales M. Muscle trigger points and pressure pain hyperalgesia in the shoulder muscles in patients with unilateral shoulder impingement: a blinded, controlled study. Exp Brain Res 2010; 202: 915-25.
11. Bron C, Dommerholt J, Stegenga B, Wensing M, Oostendorp RA. High prevalence of shoulder girdle muscles with myofascial trigger points in patients with shoulder pain. BMC Musculoskelet Disord 2011; 12: 139.
12. Dommerholt J, Fernandez-de-las-Peñas C. Trigger point dry needling: an evidence and clinical- based approach. 1st ed. London: Churchill Livingstone Elsevier; 2013.
13. APTA. Description of dry needling in clinical practice: an educational resource paper. Alexandria, VA, USA: APTA Public Policy, Practice, and Professional Affairs Unit; 2013.

14. Kietrys DM, Palombaro KM, Azzaretto E, et al. Effectiveness of dry needling for upper-quarter myofascial pain: a systematic review and meta-analysis. J Orthop Sports Phys Ther 2013; 43: 620-34.
15. Liu L, Huang QM, Liu QG, et al. Effectiveness of dry needling for myofascial trigger points associated with neck and shoulder pain: a systematic review and meta-analysis. Arch Phys Med Rehabil 2015; 96: 944-55.
16. Brady S, Mcevoy J, Dommerholt J, Doody C. Adverse events following trigger point dry needling: A prospective survey of chartered physiotherapists. J Man Manip Ther 2014: 22: 134-40.
17. Domingo A, Mayoral O, Monterde S, Santafe MM. Neuromuscular damage and repair after dry needling in mice. Evid Based Complement Alternat Med 2013; 2013: 260806.
18. Lai MW, Hong CZ. Additional ultrasound therapy after myofascial trigger point injection for the management of post-injection soreness. J Rehabil Med Assoc ROC 1998; 26: 111-8.
19. APTA - Physical therapists & the performance of dry needling: An educational resource paper. Alexandria, VA, USA: APTA Department of Practice and APTA State Government Affairs; 2012.
20. Martín-Pintado Zugasti A, Rodríguez-Fernández ÁL, García-Muro F, et al. Effects of spray and stretch on post-needling soreness and sensitivity after dry needling of a latent myofascial trigger point. Arch Phys Med Rehabil 2014; 95: 1925-1932.
21. Martín-Pintado-Zugasti A, Pecos-Martin D, Rodríguez-Fernández ÁL, et al. Ischemic compression after dry needling of a latent myofascial trigger point reduces post-needling soreness intensity and duration. PM R 2015; 7: 1026-34.

22. Lin MJ, Chen TC, Chen HL, Wu BH, Nosaka K. Low-intensity eccentric contractions of the knee extensors and flexors protect against muscle damage. Appl Physiol Nutr Metab 2015; 40: 1004-11.
23. Hermans J, Luime JJ, Meuffels DE, Reijman M, Simel DL, Bierma-Zeinstra SM. Does this patient with shoulder pain have rotator cuff disease? The Rational Clinical Examination systematic review. JAMA 2013; 310: 837-47.
24. Alqunaee M, Galvin R, Fahey T. Diagnostic accuracy of clinical tests for subacromial impingement syndrome: a systematic review and meta-analysis. Arch Phys Med Rehabil 2012; 93: 229-36.
25. Gerwin RD, Shannon S, Hong CZ, Hubbard D, Gevirtz R. Interrater reliability in myofascial trigger point examination. Pain 1997; 69: 65-73.
26. Bron C, Franssen J, Wensing M, Oostendorp RA. Interrater reliability of palpation of myofascial trigger points in three shoulder muscles. J Man Manip Ther 2007; 15: 203-15.
27. Ge HY, Fernández-de-las-Peñas C, Madeleine P, Arendt-Nielsen L. Topographical mapping and mechanical pain sensitivity of myofascial trigger points in the infraspinatus muscle. Eur J Pain 2008; 12: 859-65.
28. Hong CZ. Lidocaine injection versus dry needling to myofascial trigger point: The importance of the local twitch response. Am J Phys Med Rehabil 1994; 73: 256-63.
29. Jensen MP, Turner JA, Romano JM, Fisher L. Comparative reliability and validity of chronic pain intensity measures. Pain 1999; 83: 157-62.
30. Mintken PE, Glynn P, Cleland JA. Psychometric properties of the shortened disabilities of the Arm, Shoulder, and Hand Questionnaire (QuickDASH) and

Numeric Pain Rating Scale in patients with shoulder pain. J Shoulder Elbow Surg 2009; 18: 920-6.

31. Schmidt S, Ferrer M, González M, et al. Evaluation of shoulder-specific patient-reported outcome measures: a systematic and standardized comparison of available evidence. J Shoulder Elbow Surg 2014; 23: 434-44.
32. Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand): The Upper Extremity Collaborative Group (UECG). Am J Ind Med 1996; 29: 602-8.
33. Hervás MT, Navarro Collado MJ, Peiró S, Rodrigo Pérez JL, López Matéu P, Martínez Tello I. [Spanish version of the DASH questionnaire: Cross-cultural adaptation, reliability, validity and responsiveness]. Med Clin 2006; 127: 441-7.
34. Franchignoni F, Vercelli S, Giordano A, Sartorio F, Bravini E, Ferriero G. Minimal clinically important difference of the disabilities of the arm, shoulder and hand outcome measure (DASH) and its shortened version (QuickDASH). J Orthop Sports Phys Ther 2014; 44: 30-9.
35. Roach KE, Budiman-Mak E, Songsiridej N, Lertratanakul Y. Development of a shoulder pain and disability index. Arthritis Care Res 1991; 4: 143-9.
36. Membrilla-Mesa MD, Cuesta-Vargas AI, Pozuelo-Calvo R, Tejero-Fernández V, Martín-Martín L, Arroyo-Morales M. Shoulder pain and disability index: cross cultural validation and evaluation of psychometric properties of the Spanish version. Health Qual Life Outcomes 2015; 13: 200.
37. Roy JS, MacDermid JC, Woodhouse LJ. Measuring shoulder function: a systematic review of four questionnaires. Arthritis Rheum 2009; 61: 623-32.

38. Martín-Pintado-Zugasti A, Rodríguez-Fernández AL, Fernandez-Carnero J. Post-needling soreness after deep dry needling of a latent myofascial trigger point in the upper trapezius muscle: Characteristics, sex differences and associated factors. J Back Musculoskelet Rehabil 2016; 29: 301-308.

39. Irnich D, Behrens N, Gleditsch JM, et al. Immediate effects of dry needling and acupuncture at distant points in chronic neck pain: results of a randomized, double-blind, sham-controlled crossover trial. Pain 2002; 99: 83-9.

Legend of Figures

Figure 1: Dry needling on active trigger points (TrPs) in the infraspinatus muscle. Copyright, David G Simons Academy™, Switzerland©, with permission

Figure 2: Exercise of the shoulder musculature focussing on the infraspinatus muscle.

Figure 3: Flow diagram of patients throughout the course of the study.

Figure 4: Evolution of post-dry needling induced-pain on a numerical pain rate scale (NPRS) during the study. *Statistically significant differences between the exercise group and both placebo (detuned ultrasound) and control (no intervention) groups (P<.01).

Table 1: Baseline demographics and clinical data for the three groups*

	Eccentric Exercise (experimental)	Detuned ultrasound (placebo)	No intervention (control)	F and P values
Gender (Male / Female)	14/16	12/18	17/13	$\chi 2$=1.692; P=0.429
Age (years)	35 ± 11	37 ± 14	34 ± 13	F=0.379; P=0.686
Duration of symptoms (months)	11.7 ± 3.7	11.0 ± 2.4	12.1 ± 2.8	F = 0.363; P = 0.696
Shoulder pain (0-10) #	6.7 ± 1.8	7.4 ± 1.6	7.0 ± 1.7	F=1.152; P=0.321
DASH (0-100)	32.4 ± 16.4	29.3 ± 20.1	34.2 ± 21.2	F=0.515; P=0.599
SPADI (0-100)	38.1 ± 20.4	37.6 ± 22.5	41.8 ± 19.9	F=0.369; P=0.693

* Data are mean ± SD except for gender

Measured with a 11-point numerical pain rate scale (0, no pain; 10, worst pain imaginable)

DASH: Disabilities of the Arm, Shoulder and Hand; SPADI: Shoulder Pain and Disability Index

Table 2: Changes in Post-dry needling induced pain by group*

	Baseline	2min after[#]	24h after[#]	48h after[#]	72h after
Eccentric Exercise	5.6 ± 1.5 (5.0-6.2)	2.8 ±1.3 (2.1-3.6)	1.8 ± 1.2 (1.3-2.3)	0.6 ± 1.2 (0.1-1.2)	0.4 ± 0.9 (0.0-0.8)
Detuned ultrasound	5.2 ± 1.5 (4.5-5.8)	4.5 ± 2.1 (3.7-5.2)	3.3 ± 1.4 (2.7-3.8)	1.9 ± 2.0 (1.3-2.5)	0.8 ± 1.0 (0.4-1.2)
No intervention	5.3 ± 2.1 (4.5-5.8)	4.8 ± 2.4 (4.1-5.5)	2.8 ± 1.8 (2.3-3.4)	1.7 ± 1.7 (1.1-2.3)	1.2 ± 1.3 (0.8-1.6)

* Data are mean ± SD (95%CI)

[#] Significant differences between the eccentric exercise and detuned ultrasound/no intervention groups (ANCOVA; P<0.01)

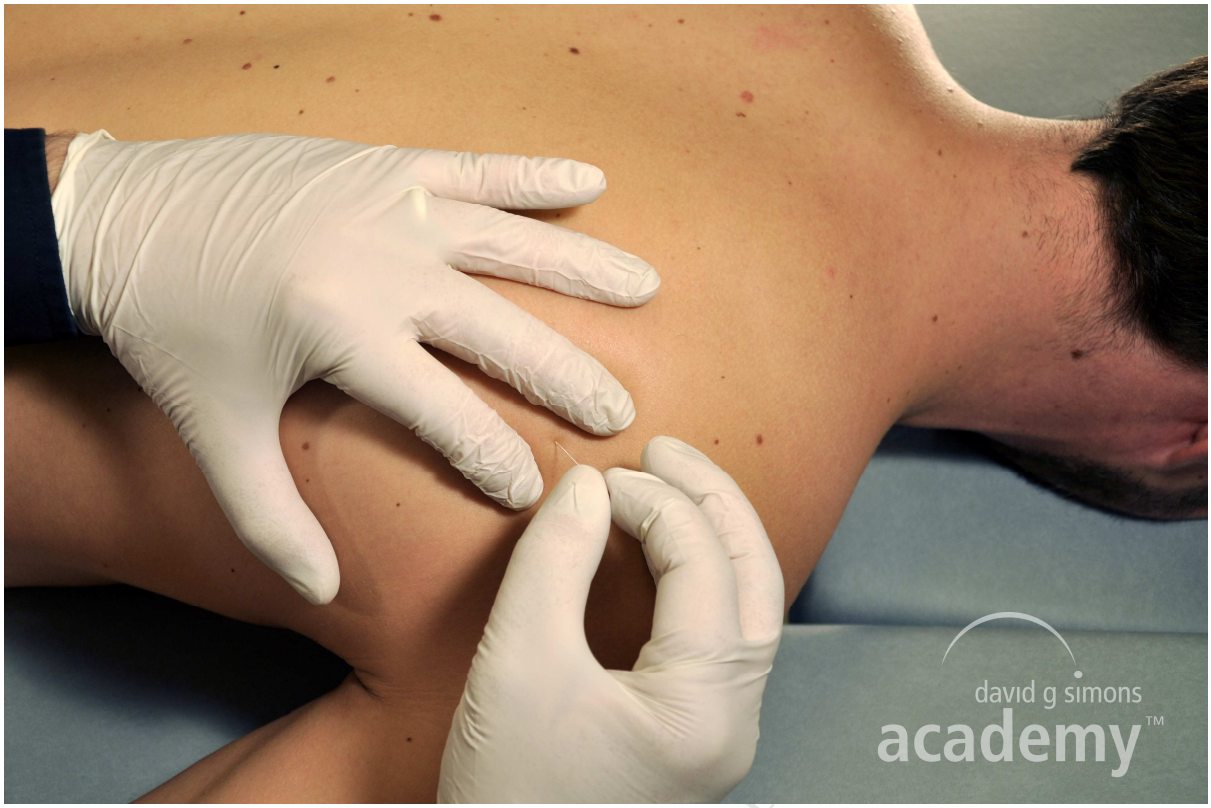
Table 3: Pre-intervention, post-intervention, and within-group change scores for shoulder pain and related-disability*

	Eccentric Exercise (experimental)		Detuned ultrasound (placebo)		No intervention (control)	
	Baseline	**72h post-intervention**	**Baseline**	**72h post-intervention**	**Pre- Baseline**	**72h post-intervention**
Shoulder pain (0-10)#	6.7 ± 1.8	3.2 ± 2.4	7.4 ± 1.6	3.7 ± 2.6	7.0 ± 1.7	4.0 ± 2.2
Within Group Change Scores	3.5 (95%CI 2.7-4.4)		3.7 (95%CI 2.5-4.8)		3.0 (95%CI 2.3-3.6)	
Shoulder related-disability						
DASH (0-100)	32.4 ± 16.4	11.4 ± 8.6	29.3 ± 20.1	11.2 ± 7.0	34.2 ± 21.2	14.1 ± 11.6
Within Group Change Scores	21.0 (95%CI 15.8-26.2)		18.1 (95% CI 11.8-24.2)		20.1 (95%CI 13.9-26.4)	
SPADI (0-100)	38.1 ± 20.4	11.0 ± 8.3	37.6 ± 22.5	11.2 ± 8.6	41.8 ± 19.9	15.5 ± 12.1
Within Group Change Scores	27.1 (95%CI 19.7-34.3)		26.4 (95% CI 19.7-33.2)		26.3 (95%CI 20.5-32.3)	

* Data are means ± SD for pre-intervention and immediate post-intervention and as means and 95%CI for within-group change scores

Measured with a 11-point numerical pain rate scale (0, no pain; 10, worst pain imaginable)

DASH: Disabilities of the Arm, Shoulder and Hand; SPADI: Shoulder Pain and Disability Index



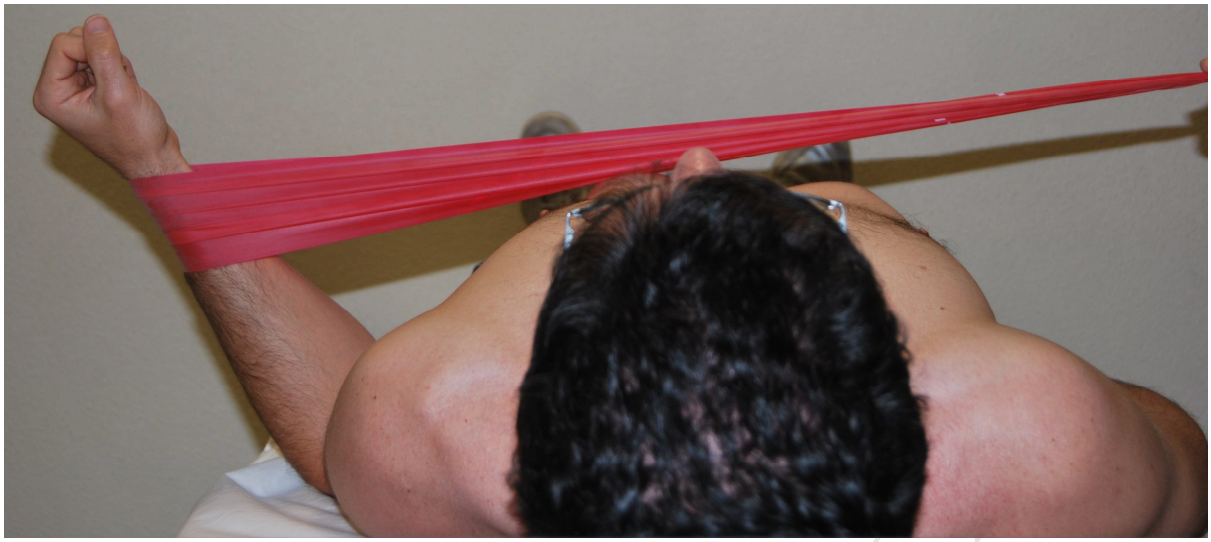


Figure 3: Flow diagram of patients throughout the course of the study